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Titanium

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Introduction

Titanium is a silvery gray, soft, ductile metal that is light weight, high in strength and low in thermal conductivity.[1,2] It is easily alloyed with other metals to improve its physical properties.[1] It is also highly reactive. This reactivity is responsible for its biocompatibility, as it forms a stable oxide layer within nanoseconds, rendering it resistant to corrosion.[2] Titanium is the fourth most abundant structural metal in the earth's crust; however, it is difficult and costly to produce.[1] Current dental applications include the use of titanium most widely for implants, orthodontic wires, endodontic files and to a limited extent crowns, fixed partial dentures and removable partial dentures.

History

An English clergyman, William Gregor, first discovered titanium in 1791.[1] It was named after the Titans of Greek mythology by Martin Heinrich Klaproth, a German chemist.[1] Titanium was not produced in large quantities until 1946, when a process was invented by William Kroll to extract titanium from its ores.[1] In 1946 the U.S. Air force recognized that titanium had high potential for use in the construction of aircraft.[1] Large amounts of federal money were poured into research, and the titanium industry was developed.[1] In addition to the aerospace industry, titanium proved useful in other applications, such as chemical processing, medicine, transportation, waste treatment and recreational industries to name a few.[1]

Titanium and implants

Titanium has been successfully used as a dental implant material since 1952 when Branemark developed a threaded pure titanium implant.[3] Four commercially pure grades of titanium, grades I-IV and two alloys Ti-6Al-4V and Ti-6Al-4V(extra-low-interstitial) can be used in the fabrication of dental implants.[4] The oxygen content and the strength increases as the grade increases and the alloys exhibit greater strength than the commercially pure titanium.[4] This becomes an important factor along with the design and size when selecting which implant to use in a specific situation.[4]

The surface oxide, titanium dioxide, provides an interface that is stable and allows bone deposition to occur close to the implant.[5] This interface is also reactive. As the oxide layer continues to grow, it incorporates organic and inorganic materials over time as it osseointegrates.[5] While titanium has been used successfully as an implant material, it is not completely bioinert.[6] Corrosion can occur when the metal is exposed to a low PH environment, mechanical stress and an oxygen deficient environment.[6] Allergies, while rare, have also been reported.[6]

Titanium uses in fixed and removable prosthodontics

Titanium can be used to fabricate removable partial dentures, fixed partial dentures, and crowns. However, its use is still limited due to the difficulties associated with casting titanium and the cost involved. Titanium has a high melting point, high reactivity, poor casting efficiency, porosity, issues with investments, and is difficult to finish.[2] Casting needs to be accomplished in an inert environment due to the increased reactivity at high temperatures with other elements.[2] If contamination does occur, the resulting product may have undesirable mechanical properties and cracks.[2] Titanium is low in density, therefore casting must be accomplished using a combination of centrifugal force, vacuum pressure and gravity.[2] Titanium requires its own investment, crucibles, porcelain and equipment, which raises the cost of fabrication substantially.[2]

The mechanical properties of commercially pure titanium are similar to type III and type IV gold.[2] The titanium alloys are similar to nickel-chromium and cobalt-chromium alloys used in removable partial dentures.[2] While the fit of cast titanium crowns and fixed partial dentures is acceptable, high noble metals in

current use have less marginal discrepancy.[7] In addition, the finishing and polishing of titanium restorations requires special tools.[3] Other methods of fabrication include spark erosion, laser welding, and machining.[2] These fabrication techniques are more predictable and precise than casting, but are costly. Advantages to using titanium for removable partial denture frameworks are its biocompatibility and that the clasps are more easily adjusted.[3] However, the alloys that are currently used can be thinner than titanium.[3]

Titanium uses in oral surgery and maxillofacial dentistry

Titanium can be used for fixation, reconstruction and replacement of craniofacial structures. Implants for craniomaxillofacial surgery are constructed of commercially pure titanium.[8] Screws, plates, sheets and external fixation devices are available. These materials can be cut and/or bent to form the shape that is needed. Prefabricated shapes are obtained by machining the metal.[8] Surface treatments are applied in order to increase the inertness of the titanium and also to prevent show-through of the metal in areas where it is in tissue close to the skin.[8]

Titanium uses in orthodontics and endodontics

Nickel titanium alloys are used for orthodontic wires and were first introduced during the 1970s. The advantages to using these wires are the low orthodontic forces generated and the wide elastic range.[3] NiTi wires have shape memory, a property that allows them to return to the manufactured shape. NiTi wires can not be welded or have permanent bends placed in them. Alternatively, β-titanium wires are free of nickel, are bendable and can be welded.[3]
Wire blanks of nickel titanium are machined to fabricate endodontic files. The advantages to these files are their super elasticity. This property makes the navigation of curved canals easier. During the machining, flaws are incorporated into the files so they are subject to fracture.[3]

Conclusion

Due to its unique properties of biocompatibility, corrosion resistance, high strength and low weight among others, titanium has had a profound impact on the practice of dentistry. In spite of the cost and complications associated with the fabrication of titanium restorations, titanium shows promise for future applications in dentistry.

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